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THE IMPORTANCE OF THE FEEDING LEVELS AND ADEQUACY ON THE MEAT QUALITY AND PRODUCTIVITY PERFORMANCE OF CROSS-BRED BULLS

Anatoly Anatolyevich VELMATOV[1], Tatyana Nikolaevna TISHKINA[2], Nikolay Nikolaevich NEYASKIN[2], and Anatoly Pavlovich VELMATOV[1]

[1]Mordovia Research Institute of Agriculture, Saransk, Republic of Mordovia, Russia
[2]Ogarev Mordovia State University, Saransk, Republic of Mordovia, Russia

Email: nneyaskin@gmail.com

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ABSTRACT: The study aimed to determine the effect of the level and adequacy of feeding on the dynamics of live weight and meat productivity of Simmental × Holstein bulls with a close blood relationship (87.5%) for the Holstein breed. Three groups of bulls with 87.5% Holstein heredity in the genotype were formed, out of which two groups were experimental and one group served as a control group. The bulls of the control group received a diet compiled according to detailed standards, and their analogs from the experimental groups had a diet exceeding the norm by 10 and 20%, respectively. During the entire growing period, the bulls of the 1st experimental group consumed 3,564 energetic feed units (EFU) and 362.5 kg of digestible protein (DP); the 2nd experimental group consumed 3,875 EFU and 394.3 kg DP; and the control group consumed 3,245 EFU and 329.9 kg DP, respectively. In terms of carcass yield, bulls of the first and second experimental groups outperformed the ones from the control group by 2.41% and 3.92%. With an increase in the level of feeding in experimental bulls, fat deposition accelerated; thus, the meat of bulls of the experimental groups contained 2.13% and 2.54% more fat than in animals of the control group. At the same time, the protein content in the meat of experimental bulls decreased by 0.15 and 0.22% in comparison with the control group. The energy value of 1 kg of meat of experimental bulls was higher by 0.77-0.90 MJ. It can be concluded that a possible increase in the meat productivity of bulls-crossbreeds of the Holstein breed with a close blood relationship and the determination of planned indicators of animal growth should be taken into account when developing breeding programs.

Keywords: Breed, Bulls, Carcass yield, Genotype, Live weight.

INTRODUCTION

The use of Holstein bulls for cross-breeding with local cattle breeds in almost many countries with developed dairy cattle breeding is one of the promising fields for increasing their milk productivity and udder technology (Tuzov et al., 2018; Rodríguez-Bermúdez et al., 2019). At the same time, studies indicate that the meat productivity of young animals decreases in crossbreeds which obtained for propose of milk yield (Bown et al., 2016). However, the analysis shows that the results obtained by different researchers are contradictory, as the observations were conducted on animals of different body types and different levels of feeding (Pfuhl et al., 2007; Venkata Reddy et al., 2015; Velmatov et al., 2018).

The formation of meat productivity and the carcass yield in cattle depends on the rearing quality of young animals (Hozáková et al., 2020; Lamanov et al., 2020). Numerous studies have established that with proper organization of breeding, and in re results stated that animals can be fatten faster with less feed consumption, due to optimum nutritional management (Wanapat et al., 2015; Hozáková et al., 2020; Lamanov et al., 2020). Currently, dairy and double-proposed breeds show the same gains as the cattle of meat breeds, in young age (Hietala and Juga, 2017; Berry et al., 2019). This is especially important in the first months of postnatal development since this phase largely determines subsequent productivity (Hietala and Juga, 2017; Berry et al., 2019).

In Russia, almost all farms with different levels of feed availability and located in different natural and climatic conditions have mainly the Holstein breed (Sidorova, 2016). The analysis of the production situation of numerous farms shows that the problem of full-fledged feeding is quite urgent (Bostanova et al., 2021; Semkiv, 2021). In this regard, In the breeding program for meat production, dietary energy levels is a key factor in nutritional management, and it should be controlled with any cross-breeding programs, especially for meat propose (Osadchuk et al., 2017; Velmatov et al., 2018).

Therefore, the objective of present study was to evaluate the dynamics of live weight and meat productivity of cross-bred Simmental × Holstein young animals of the third generation with a different energy level and amount of feed.

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MATERIALS AND METHODS

Ethical regulation

In the course of the current study all procedures were conducted in accordance with the Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes and approved by institutional ethical review committees in Mordovia Research Institute of Agriculture and Ogarev Mordovia State University).

Experimental design

At the Agrosoyuz LLC of the Ruzaevsky district of the Mordovian Republic (Russia), three groups of bulls with 87.5% of Holstein heredity in the genotype were formed: two experimental groups and one group serving as a control variant, with 20 heads in each group. The bulls were selected according to the principle of analog pairs, taking into account the genotype and live weight. When compiling the diets for the control group bulls, we used the recommendations of the L.K. Ernst Federal Research Center for Animal Husbandry (VIZh, 2021; Marinchenko, 2021), and the bulls from the experimental groups received 10% or 20% more nutrients, in comparison with control.

To study the dynamics of the live weight of bulls, individual weighing was assayed at birth, and 3, 6, 9, 12, 15, and 18 months of age. The average daily, absolute, and relative gains in live weight were determined. To study the meat productivity of steers, we used the methodological recommendations of the All-Union Academy of Agricultural Sciences (VASKhNIL, 2019), and the All-Russian Research Institute of Medical Device Industry (Levantin et al., 2019). The slaughter of bulls was carried out at the Ichalkovsky meat processing plant of the Republic of Mordovia for 5 animals from each group. During the slaughter, the following indicators were taken into account: live weight (removable and pre-slaughter), carcass weight, fat weight, slaughter yield of carcass and fat (kg, %), internal organ weight, fresh skin weight

When studying the chemical composition of meat, a general sample of meat was used. To determine the content of protein, fat, and ash in meat, the following methods were used:

- Moisture content by drying the sample weight to a constant weight at a temperature of 105±2C;
- Protein content by the method of determination of total nitrogen by the Kjeldahl method (Kirk, 1950) in combination with isometric distillation in Conway's vessels;
- Fat content by extracting the dry sample weight with ether in the Soxhlet apparatus;
- The content of mineral substances (ash) by dry mineralization of samples in a muffle furnace at a temperature of 450-600 C according to the VIZh method (Levantin et al., 2019).

In present experiments, the first feeding of calves with colostrum was performed during the first 30 minutes after birth. The amount of colostrum consumed on the first day of life was 4-5 kg. At the same time, the health status of the calf was taken into account. During the dairy period, its tried not to overload the developing digestive system, to avoid digestive disorders, and also to achieve the necessary level of growth. Young calves from the age of 3 days received dry food (high-fiber) in the form of starter compound feed and whole grains of oats and corn in equal proportions. The use of starter feed and grain feeds makes it possible to transfer calves to coarse feed at an earlier time, which reduces milk consumption and labor costs and allows obtaining a developed calf capable of eating a large amount of vegetable feed. The size of granules and grains, and their physical characteristics are of no small importance for the correct starter feed and grain feed. The rough texture of the feed is preferable for the calf. In this connection, the consumption of dry matter increases with the inclusion of whole or slightly flattened corn, but not ground corn.

Statistical analysis

The data obtained in the course of the study were processed by the method of variation statistics proposed by SPSS software, with ANOVA method (P value in 0.05) (George and Mallery, 2019). The reliability of the indicators was assessed by Student's t-test.

RESULTS AND DISCUSSION

The feed of the farm's production was introduced into the diet of bulls, containing alfalfa hay, alfalfa haylage, corn silage and concentrates. It should be noted that hay and haylage are harvested in the budding phase of plants, and corn silage is harvested in the wax ripeness phase.

During the entire growing period, the bulls of the control group consumed 3245 energetic feed units (EFU) and 329.9 kg of digestible protein (DP) per head, the bulls of the first experimental group consumed 3564 EFU and 362.5 kg of DP, and the bulls of the second experimental group consumed 3875 EFU and 394.3 kg of DP, respectively. One EFU contained 101.7 g of DP (Table 1).

Intensive breeding following established feeding standards had a significant impact on the dynamics of the live weight of experimental animals (Table 2). Thus, at the age of three months, experimental bulls reliably outperformed the ones from the control group in live weight by 7.9 kg (8.1%; $P \leq 0.01$) and 10.8 kg (11.0%; $P \leq 0.001$). At six months of age, the difference increases to 16.4 kg (9.4%; $P \leq 0.001$) and 22.5 kg (12.9%; $P \leq 0.001$), at nine months of age by 17.9 kg (7.1%; $P \leq 0.01$) and 33.1 kg (13.1%; $P \leq 0.001$) at twelve months of age by 26.2 kg (8.2%; $P \leq 0.01$) and 55 kg (17.2%;

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P≤0.001), at fifteen months of age 33.6 kg (8.7%; P≤0.01) and 67.2 kg (17.5%; P≤0.001) and at eighteen months of age by 39.5 kg (8.6%; P≤0.001) and 73.8 kg (16.4%; P≤0.001).

When studying the dynamics of average daily gains, the unequal intensity of the weight gain in bulls was established. Differences in average daily gain were observed from birth to three months of age. The advantage of bulls of the experimental groups in this age period was 100 g (15.3%; P≤0.01) and 114.6 g (17.6%; P≤0.01)

From three to six months of age, the advantage of bulls of the experimental groups remained and amounted to 94.4 g (11.1%;) and 130.5 g (15.4%). A similar pattern was observed from six to nine months of age. Significant differences were noted between the bulls of the control and the second experimental group in the age period from nine to twelve months of age, equaling 243.9 g (32.1%; P≤0.001) (Table 3).

For the entire period, from birth to 18 months of age, the bulls of the second experimental group were characterized by a large average daily gain, so the difference between the bulls of the control group and the second experimental group was 136 g (17.9%; P≤0.05), and between the bulls of the control and the first experimental group, it equaled 73.6 g (9.7%; P≤0.05). When studying meat productivity, a control slaughter of bulls was carried out at the age of 18 months, when five heads from each group were slaughtered (Table 4).

Table 1 - Feed consumption by animals of experimental groups from birth to 18 months of age

Groups / Indicator	Control	Experimental	
		1st	2nd
Milk, kg	270	295	325
Milk replacer, kg	20	22	24
Prestarter feed, kg	45	57	75
Starter feed, kg	176	200	230
Hay, kg	239	197	177
Haylage, kg	4,010	4,183	4,295
Silage, kg	1,892	2,237	2,338
Straw, kg	305	305	305
Concentrates, kg	691	760	881
Energetic feed units (EFU)	3245	3564	3875
Digestible protein (DP), kg	329.9	362.5	394.3
DP content in 1 EFU	101.7	101.7	101.7

Table 2 - Dynamics of live weight of bulls, kg (X ± Sx)

Groups / Age, months	Control	Experimental	
		1st	2nd
At birth	39.7±0.57	39.2±0.55	40.0±0.49
3	97.6±1.80	105.5±1.62**	108.4±1.63***
6	173.9±3.54	190.3±4.01***	196.4±2.92***
9	251.1±4.93	269.0±3.68**	284.2±3.92***
12	319.5±5.47	345.7±5.44**	374.5±4.49***
15	384.4±7.92	418.0±5.25**	451.6±4.85***
18	450.9±8.21	489.9±6.02***	524.7±5.32***

*P≤0.05, **P≤0.01, ***P≤0.001 data are reliable.

Table 3 - Dynamics of the average daily weight gain of bulls, g (X±Sx)

Groups / Age, months	Control	Experimental	
		1st	2nd
0-3	643.3±25.45	737.2±22.78	760.0±23.61
3-6	847.8±39.34	942.2±48.87*	978.3±40.21*
6-9	857.2±47.27	873.9±48.62*	975.0±28.71*
9-12	760.0±39.94	852.2±43.79*	1,003.9±36.85***
12-15	721.1±99.58	803.9±49.94	856.1±58.87
15-18	738.9±86.37	798.9±61.73	812.2±47.47
0-18	761	834.6	897

*P≤0.05, **P≤0.01, ***P≤0.001 data are reliable.

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Table 4 - Slaughter indicators of bulls, (X±Sh)

Indicator \ Groups	Control	Experimental	
		1st	2nd
Pre-slaughter live weight, kg	427.0±2.24	454.8±4.38	492.8±5.28
Hot carcass weight, kg	230.4±1.85	256.4±2.11***	282.5±3.08***
Carcass output, %	53.96±0.45	56.37±0.29***	57.88±0.86***
Internal fat weight, kg	8.46±0.77	8.90±1.01	10.10±1.15
Fat output, %	1.98±0.22	1.95±0.27	2.05±0.27
Slaughter yield, %	55.93±0.49	58.32±0.24***	59.93±0.55***

*P≤0.05, **P≤0.01, ***P≤0.001 data are reliable.

Before slaughter, the fatness of the bulls was evaluated and was recognized as the highest in all animals. The carcasses obtained during slaughter were assigned to the first category. During the visual assessment of the carcasses of bulls of the second experimental group, they were distinguished by a large development of subcutaneous fat. In the bulls of the control group, this feature was less pronounced. Intensive feeding has left its mark on the formation of the muscles of the animals' torso. The bulls of the second experimental group had well-developed legs and a developed muscled trunk.

The heaviest carcasses were obtained from bulls of the second experimental group. Their advantage over the control group was 52.1 kg (22.6%; P≤0.001), and bulls of the first experimental group outperformed animals from the control group by 26.0 kg (11.3%; P≤0.001). In terms of carcass yield, bulls of the first and second experimental groups outperformed the ones from the control group by 2.41 and 3.92% (P≤0.001), and a similar pattern was observed in the slaughter yield. This finding is in agreement with Cattelam et al. (2018) who reports high-grain diets increase energy and carcass yield of fattening cows. Also its in according to Qiu et al. (2020) who stated high-energy diets in Holstein steers improves growth rate of animals and carcass yield. Also, in this regard, Nogalski et al. (2018) showed that During the fattening period, a higher proportion of concentrate (higher energy) in the ration contributed to higher feed intake, higher feed efficiency and more desirable carcass characteristics, which it observed in present study for cross-bred animals.

There were no significant differences in the output of internal fat between the animals of the first experimental group and the control group. This finding in in agreement with Jones et al. (1985) who reported no differences in the proportion of carcass weight relative to empty body weight for animals fed concentrate or forage diets. The bulls of the first and second experimental groups outperformed the ones from the control group by 0.44-1.64 kg (5.2-19.4%) (Table 4). Concerning the skin weight, one could note the superiority of the bulls from the experimental groups. Thus, the bulls of the first and second experimental groups outperformed the animals from the control group by 2.66 kg (8.4%; P≤0.01) and by 7.8 kg (24.7%; P≤0.001). The absolute weight of the head, front and hind legs in the control group bulls were lower than in the experimental groups.

Concerning the weight of internal organs and by-product yield one can note the advantage of the second experimental group bulls over the control group animals: the heart weight exceeded that of the control group by 0.7 kg (45.4%; P≤0.001), the lung weight by 0.96 kg (50.3), the liver weight by 1.68 kg (32.4%; P≤0.001), and the kidney weight by 0.32 kg (P≤0.05) (Table 5). As a result of the carcass dissection, intergroup differences in the morphological composition were revealed.

Table 5 - The weight of organs and tissues, kg (X±Sh)

Indicator \ Groups	Control	Experimental	
		1st	2nd
Skin	31.60±0.61	34.26±0.98**	39.40±0.54***
Head	15.74±0.29	15.90±0.30	16.26±0.41
Tongue	0.78±0.04	0.80±0.06	1.04±0.16
Front legs	4.66±0.13	4.70±0.13	5.32±0.08
Hind legs	5.16±0.19	5.32±0.24	6.50±0.24
Testes	0.78±0.04	0.85±0.04	0.82±0.02
Heart	1.54±0.05	1.80±0.09	2.24±0.08***
Lungs	3.42±0.10	4.38±0.33	5.14±0.44***
Liver	5.12±0.13	5.66±0.23	6.80±0.31***
Kidneys	1.20±0.08	1.34±0.12	1.52±0.09*
Spleen	0.72±0.03	0.86±0.05	1.08±0.12

*P≤0.05, **P≤0.01, ***P≤0.001 data are reliable.

The carcasses of the experimental groups differed by the greater absolute flesh weight. Their advantage compared to the control group was 24.0 kg (13.4%; P≤0.001) and 43.8 kg (24.4%; P≤0.001). The absolute bone weight was lower in

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the control group compared to the experimental ones by 3.2 kg (7.4%) and 6.8 kg (15.8%) (Table 6). There were no significant differences in the weight of cartilage and tendons between the groups of animals. After dissecting, it was found that in the half-carcasses of experimental bulls, the flesh weight, expressed as a percentage of the carcass weight, was greater, and the bone weight was less, therefore, their meat index was 0.13-0.39% higher compared to the control group. The study of the chemical composition of the general sample showed that the dry substance content was the highest in the meat of bulls of the experimental groups, being 1.95% (P≤0.01) and 2.27% (P≤0.01) higher than the meat of bulls of the control group.

Table 6 - Morphological composition of bull carcasses, (X±Sh)

Group	Carcass weight, kg	Flesh		Bones		Cartilage and tendons		Meat index, %
		kg	%	kg	%	kg	%	
Control	230	179.6	78.08	43.0	18.69	7.4	3.22	4.17
1st experimental	257.6	203.6***	79.03	46.2	17.93	7.76	3.02	4.30
2nd experimental	282.0	223.4***	79.22	49.8	17.66	9.2	2.98	4.56

*P≤0.05, **P≤0.01, ***P≤0.001 data are reliable.

Table 6 - Chemical composition of the general meat sample

Indicator / Groups	Control	Experimental	
		1st	2nd
Moisture	68.51±0.36	66.56±0.39	66.24±0.33
Dry matter	31.49±0.36	33.44±0.39**	33.76±0.33**
Protein	19.45±0.10*	19.30±0.39	19.23±0.09
Fat	11.18±0.36	13.31±0.62**	13.72±0.31**
Ash	0.86±0.02	0.83±0.02	0.80±0.02
The protein and fat ratio	1:0.57	1:0.69	1:0.71
Caloric content of 1 kg of meat, MJ	4.16	4.93	5.06
Protein content in the carcass, kg	34.8	39.2	43.0
Fat content in the carcass, kg	20.0	27.0	30.6

*P≤0.05, **P≤0.01, ***P≤0.001 data are reliable.

With an increase in the level of feeding in experimental bulls, fat deposition accelerated; thus, the meat of bulls of the experimental groups contained 2.13% (P≤0.01) and 2.54% (P≤0.01) more fat than in animals of the control group. Present findings are in agreement with Hornick et al. (1998) who stated higher dietary concentrations in energy and protein, had higher carcass contents (connective and adipose tissue) whereas these animals had lower meat-fat content. Honig et al. (2020) showed that carcass fat increased during growth primarily due to feeding high-energy diet. This may be occurred due to expense of bone and subsidiary muscle tissue in this period. Also, Omarov et al. (2017) suggested similar feeding method (high level of energy levels with special oil seeds) for improve meat quality and develop marble beef production in Russian conditions.

At the same time, the protein content in the meat of experimental bulls decreased by 0.15 and 0.22% (P≤0.05) in comparison with the control group. This finding is in agreement with De Smet et al. (2000) which increased dietary concentration of some major nutrients can change energy/protein ratio in beef, whereas increased daily weight gain during different stages of the fattening period. Therefore, the ratio of protein and fat in experimental animals was not the same. These differences in energy/protein ratio in meat, due to high-energy diets have been reported and stated by Cantalapiedra-Hijar et al. (2018), Mwangi et al. (2019), and Maresca et al. (2019).

Thus, in animals of the control group, it was 1:0.57, in the first experimental group 1:0.69, and the second experimental group 1:0.71. The meat of the bulls of the experimental groups was more caloric than the meat of the animals of the control group. The energy value of 1 kg of meat of experimental bulls was higher by 0.77-0.90 MJ (Table 8). Present findings (Table 8), are in agreement with Siddiki et al. (2021) in their practice on buffaloes. Based on the conducted study, it should be noted that for Holstinized animals it is necessary to create optimal conditions for feeding and keeping, which makes it possible to identify the genetically determined productivity potential as much as possible while increasing the efficiency of their breeding.

An increase in the energy nutritional value of diets by 10-20% makes it possible to increase the live weight by 39.0-73.8 kg, to get bulls with a live weight of 489-524 kg. The relative growth rate, which reflects the intensity of the growth of bulls, shows that with an increased type of feeding, the growth rate increases at a young age. From birth to 18 months of age, the bulls of the second experimental group were characterized by a large average daily increase. Thus, the difference

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between the bulls of the control group and the second experimental group was 136 g (17.9%; P≤0.95), and between the bulls of the control and the first experimental group, it equaled 73.6 g (9.7%; P≤0.95).

At the same time, the quality characteristics of the carcass were improved. The ratio of flesh and bones with an increase in the feeding level by 20% was 4.56, with an increase in the feeding level by 10%, the ratio was 4.30 and in the control group, it was 4.17. At the same time, each carcass contained 73.6 kg, 66.1 kg, and 54.6 kg of protein and fat, respectively, the difference between the second experimental group and the control group was 34.7%, and between the first experimental group and the control group, it was 21.1%. At the same time, the differences in live weight before slaughter were 15.4% and 6.5%. With an increase in the level of feeding, the yield of valuable cuts, the yield of meat, protein, and fat increased.

CONCLUSION

The study data demonstrate the existence of early maturing animals which, with an increase in the level of feeding, can intensively increase live weight at a young age. The feeding system and the nature of growth had a significant impact on the formation of meat productivity and the quality indicators of the meat obtained from them. When developing breeding programs, it is necessary to take into account the possible increase in meat productivity of Holstein crossbred bulls with a close blood relationship and the determination of planned indicators of animal growth. All this should be taken into account when developing the technology of raising young animals for meat and determining the quality of products.

DECLARATIONS

Corresponding author

Nikolay Nikolaevich Neyaskin; email: nneyaskin@gmail.com ; ORCID ID: https://orcid.org/0000-0003-0526-8340

Authors' contribution

All the authors had similar roles in conceptualizes investigations, data collection, data analysis, laboratory analysis and manuscript writing.

Conflict of interests

The authors have not declared any conflict of interests.

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